University of Ottawa

Department of Computer Science

ITCS812 Automata and Formal Languages

Quiz 1 (Answer 1)

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Q1. What language does this grammar generate?

$S \rightarrow aaS \mid A$

$A \rightarrow bbbA \mid \lambda$

Q2. Find a grammar for the following language

$L=\{w \in \{0,1\}^* : w \text{ has an even number of 1's}\}$

$S \rightarrow A1A1AS \mid \lambda$

$A \rightarrow 0A \mid \lambda$

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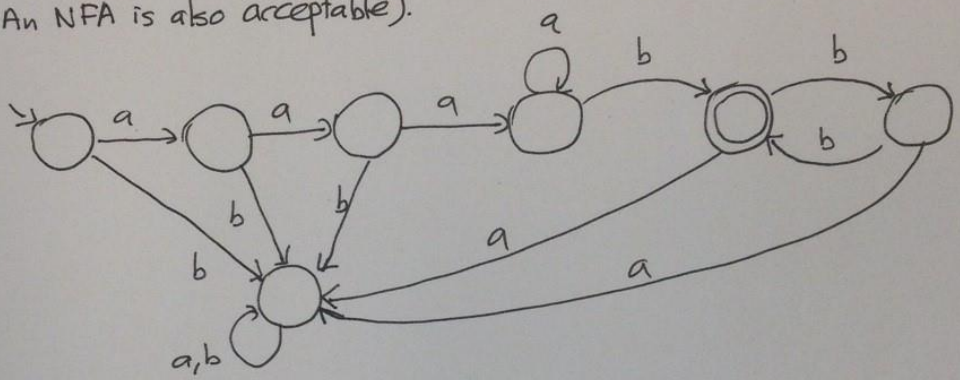
Quiz2

Problem 1.

Find a finite automaton for L given that

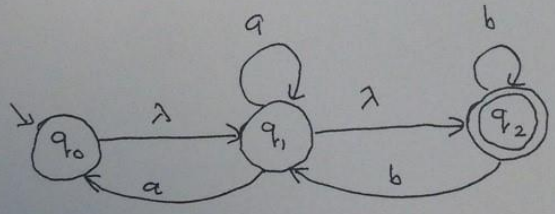
$$L=\{a^n b^m : n>3 \text{ and } m \text{ is odd}\}.$$

DFA: (An NFA is also acceptable).

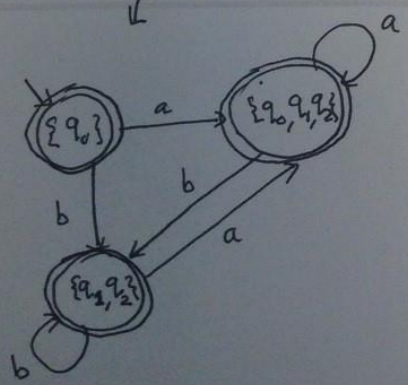


Problem 2.

Convert the following NFA to a DFA.



DFA



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Quiz 3 (Sections 3.1+3.2+3.3)

Q1. Find a regular expression for the following language. Assume that $\Sigma=\{a,b\}$.

$$L=\{ w\in\{a,b\}^* : n_a(w) \bmod 3 > 0 \}$$

Notice that the words in this language are not ordered in terms of a's and b's.

Answer: $r=(b^*ab^*ab^*ab^*)^*\cdot(ab^* + ab^*ab^*)$

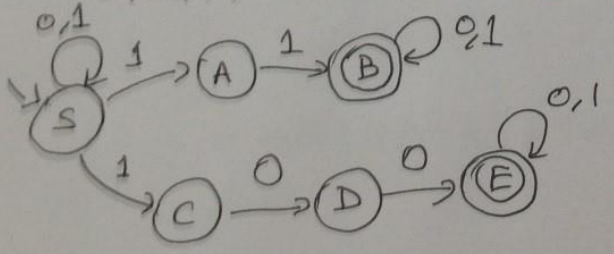
↑ this makes words with a's as a multiple of 3's

↑ followed by one or two a's to make it >0

Q2. Find a regular grammar denoting the following language.

$$L=\{ w\in\{0,1\}^* : w \text{ must contain the pattern } 11 \text{ or } 100 \}$$

First draw an NFA for the language



Now convert it to a right-linear grammar

$S \to 0S \mid 1S \mid 1A$

$A \to 1B$

$B \to 0B \mid 1B \mid \lambda$

$S \to 1C$

$C \to 0D$

$D \to 0E$

$E \to 0E \mid 1E \mid \lambda$

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Quiz4 (Take Home)

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Problem 1.

Show that given two regular languages L_1 and L_2, then $L_1 - L_2$ is regular.

if L_1 is regular Language & L_2 is regular language then L_1 & $\bar{L}_1$ is also regular using the closure properties of regular Languages.

also $L_1 \cap L_2 \rightarrow$ regular

$\bar{L}_1$ & $\bar{L}_2 \rightarrow$ regular

$\Rightarrow \therefore L_1 \cap \bar{L}_2 \Rightarrow$ is regular

Demorgan's Law :-

$L_1 \cap L_2 = \bar{L}_1 \cup \bar{L}_2$

$L_1 - L_2 = L_1 \cap \bar{L}_2$

Problem 2.

Show that $L=\{ a^n b^l c^k : k \neq n+l \}$ is not regular. $L_1 = \{a^n b^l c^k : k = n+l\}$

$\Rightarrow$

Let $\omega = a^m b^m c^{2m}$ $\quad |\omega| \geq m$

$\omega = xyz$

Since $|xy| \leq m$ & $|y| \geq 1$

$y = a^k$ $\quad 1 \leq k \leq m$

$\omega_2 = xy^2z \Rightarrow a^{m+t} b^m c^{2m}$

$\omega_1 \notin L \Rightarrow 2m \neq (m+t)+m$

$\therefore L_1$ is not regular using the pumping Lemma.

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Quiz #5

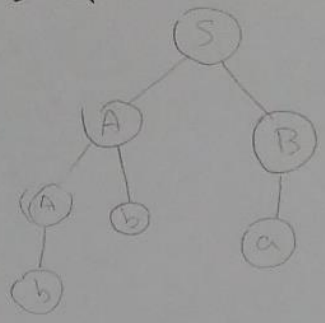
problem 1 :-

Show that the following gramar is ambiguous

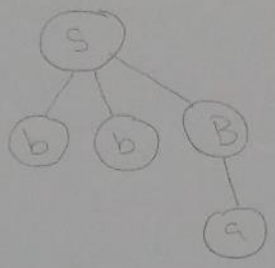
$S \longrightarrow AB \mid bbB$

$A \longrightarrow b \mid Ab$

$B \longrightarrow a$



w = bba



w = bba

problem 2 :-

show that $L = \{ a^n b^m c^k : 2n+m=k \}$ is context-Free

$S \longrightarrow aaS\,cc \mid A$

$A \longrightarrow \cancel{\in} \mid \cancel{aBb} \mid \cancel{bB} \mid \cancel{A} \mid bAc$

$B \longrightarrow \in$

n=0 m=0

n=1 m=1

2+1 = 3k

n=2 m=2

4+2 = 6k

n=3 m=1

6+1 = 7k

n=0 m=1

0+1 = 1

aaaabb^cc

aabccc

① $S \longrightarrow aSCC \mid A$

$A \longrightarrow bAc \mid \lambda$

② $S \longrightarrow aaScc \mid A$

$A \longrightarrow bAC \mid \lambda$

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Q1. Remove all the unit, useless, and λ-productions from the following grammar.

$S \to aSb \mid aA \mid B$

$A \to aC \mid \lambda$

$B \to aB \mid D$

$C \to a \mid aa \mid bC$

$D \to aBa$

① Remove λ-prod.

$V_N = \{A, S\}$

$S \to aSb \mid aA \mid a \mid B$

$A \to aC \mid a$

$S \to aB \mid D$

$C \to a \mid aa \mid bC$

$D \to aBa$

② Remove unit-prod.

$S \to B \to D$

$S \to aSb \mid aA \mid a \mid aB \mid aBa$

$A \to aC \mid a$

$B \to aB \mid aBa$

$C \to a \mid aa \mid bC$

$D \to aBa$

③ Remove useless prod containing

D – unreachable

B – endless

$S \to aSb \mid aA \mid a$

$A \to aC \mid a$

$C \to a \mid aa \mid bC$

Q2. Convert the following context-free grammar to Chomsky Normal Form.

$S \to X_a S X_b \mid X_a X_a S X_b \mid X_a X_a X_a S X_b \mid \lambda \mid b$

$A \to X_b$

step1. $X_a \to a$

$X_b \to b$

$S \to X_a B \mid CD \mid CE \mid b$

step2. $A \to b$

$X_a \to a$

$X_b \to b$

CNF $B \to S X_b$ $\quad E \to X_a D$

$C \to X_a X_a$

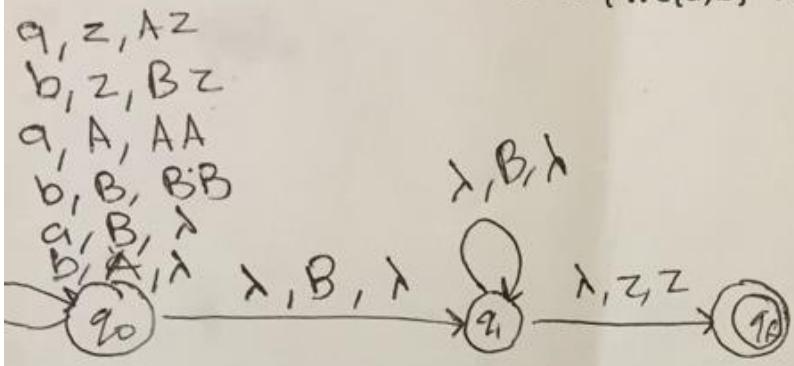
$D \to S X_b$

Quiz 7

10/10

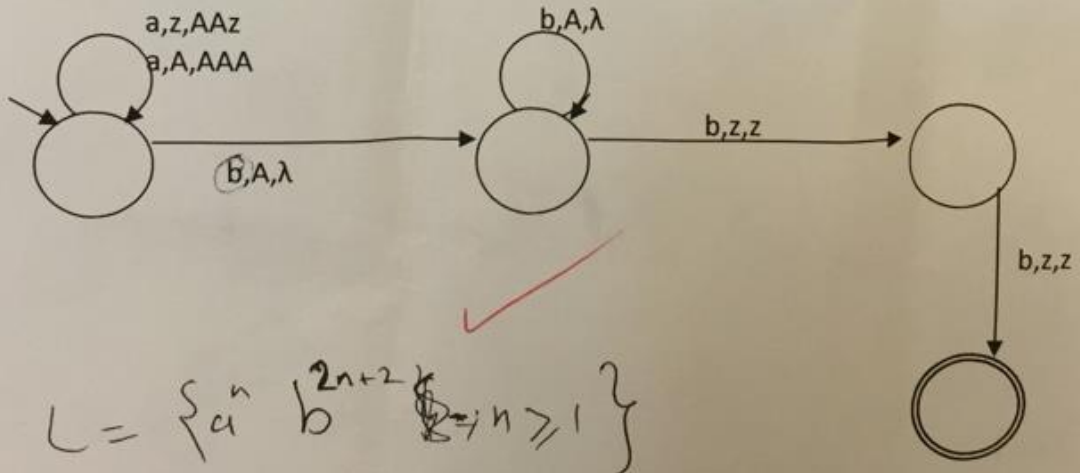
Problem 1.

Build an NPDA for the language $L=\{ w\epsilon\{a,b\}^* : n_a(w) < n_b(w)\}$.



Problem 2.

What is the language accepted by the following NPDA?



$L = \{ a^n b^{2n+2} \mid n \geq 1 \}$

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Quiz 9

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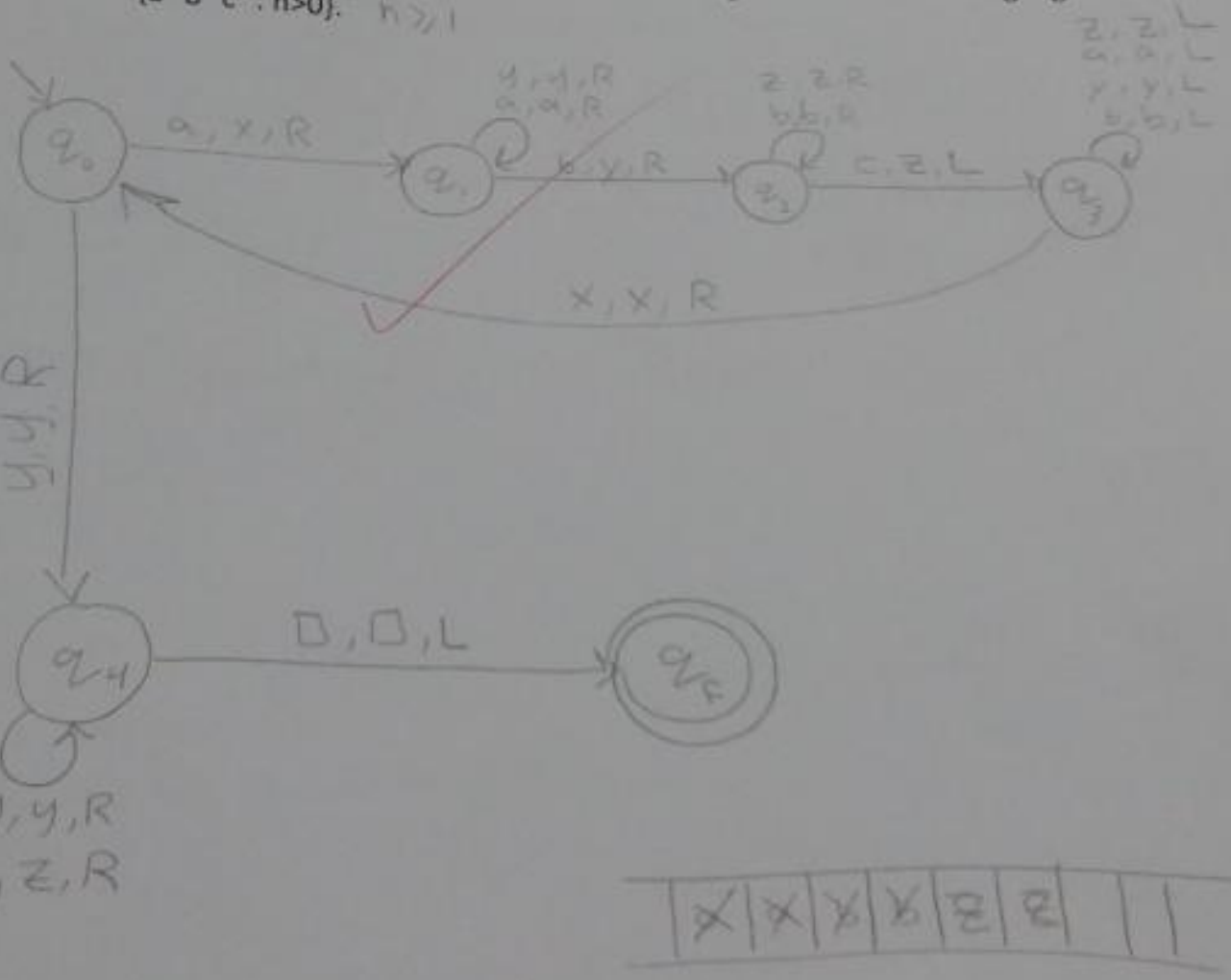
Problem 1.

Construct the transition function for the Turing Machine for the language $L=\{a^n b^n c^n : n>0\}$. $n \geq 1$



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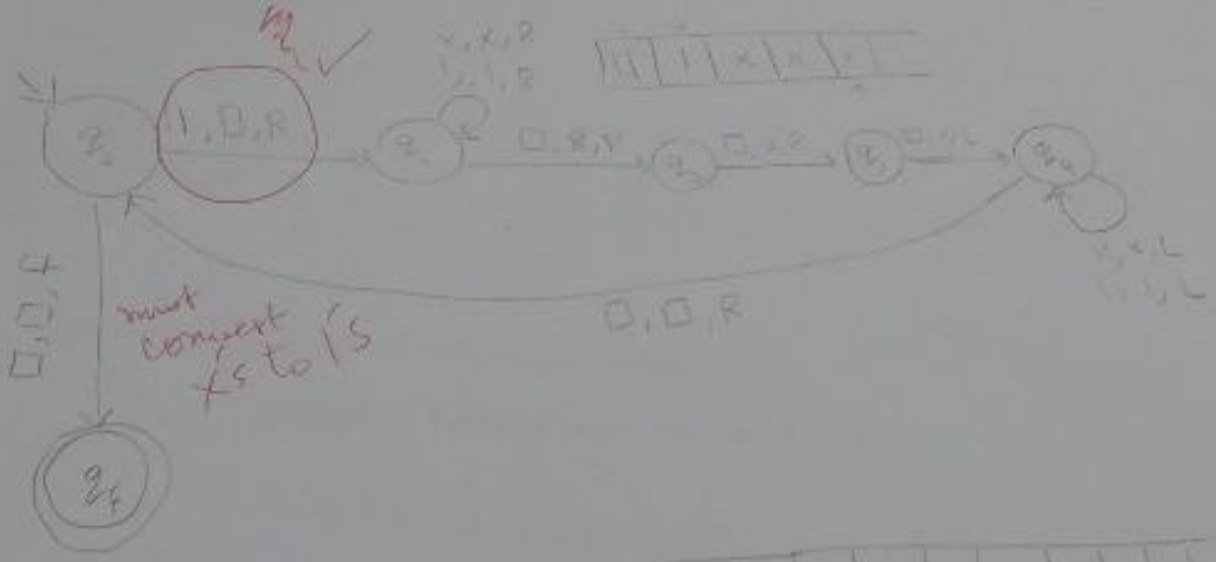
Problem. Quiz Ch.9b

Show that the function $f(x)=3x$ is Turing-computable over the domain of the positive integers.



The language is accepted by Turing machine